Task 4 Evaluation Criteria Scoring Systems

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The purpose of this technical memorandum (TM) is to document the scoring system that will be employed in Task 4 of the City of Alexandria Storm Sewer Capacity Analysis (CASSCA). The focus of Task 4 is prioritization of problem areas based on Task 2 modeling results, development of solutions to resolve the problem areas, then prioritization of solutions. The prioritization process will be similar for both problems and solutions and includes several distinct steps:

- **Define evaluation criteria** – Evaluation criteria for problems and solutions were defined during the Task 4 workshop with input from City of Alexandria staff. These criteria are summarized in this TM and will be used to assess the severity of problems and the benefit of solutions.
- **Weight evaluation criteria** – Each evaluation criterion was assigned a weight (0-100) by Task 4 workshop participants. The weights quantify the relative importance of each evaluation criteria and build a defensible foundation for project ranking.
- **Define scoring system** – A scoring system will be developed for each evaluation criteria to provide a method for ranking problems and solutions within evaluation criteria. Scoring systems for problem and solution evaluation criteria are defined in this TM.
- **Score and rank alternatives** – Problems will be identified and ranked using the problem area evaluation scoring system. Solutions will be identified, and then scored and ranked using the solution evaluation scoring system.
    - *Score and Rank Problems* – Each junction will be scored using the methods outlined in *Task 4 Problem Area Evaluation Criteria Scoring System*. A score of 0-10 will be assigned to all stormwater junctions in the system for each evaluation criteria. Weights will then be applied to the score calculated for each evaluation criteria to come up with an overall score for each junction. This overall score will be used to rank problems. Solutions will be investigated for the priority problem areas with the highest scores.
    - *Score and Rank Solutions* – Solutions will be developed for the problem areas identified in the previous step. Each solution will be scored using the methods outlined in this TM. A score of 0-10 will be assigned to solutions for each evaluation criteria. Then the weights will be applied to the score calculated for each evaluation criterion to come up with an overall benefit score. The cost of each solution will also be estimated. Solutions will be ranked based on the overall benefit score, as well as the cost benefit score, which is the overall benefit score divided by the cost of the solution in millions of dollars.
- **Perform 'what if' analysis to refine process** – After completing the prioritization, the process may need to be refined if the results did not meet the expectations of the City. This may include adjusting the weighting and scoring schema.

- **Evaluate watershed-wide scenarios** – Once individual solutions have been evaluated, the solutions will be grouped into three alternative watershed-wide scenarios. The scenarios will be scored using similar criteria to the individual solutions, with some modifications. The purpose of taking this watershed wide look at solutions sets is to evaluate the solutions in a holistic, system-wide manner and prevent the selection of upstream capacity solutions that create or exacerbate downstream capacity issues. This will also provide an additional basis for selection the set of solutions provides the greatest benefit for the most efficient cost. This will be further documented and evaluated later in the project.

The evaluation criteria and scoring systems are defined in greater detail in the following sections. An example is provided for clarity, but does not necessarily reflect a viable project location. Some of the data in the example has been generated for the purpose of demonstrating the scoring and should not be used for any other purpose.

Problem Area Evaluation

Though model results have been presented for pipes, not junctions, in the Stormwater Capacity Analysis (Task 2), flooding occurs at a junction and not along the length of the pipe; therefore junctions will be scored for each of the problem area evaluation criteria, which include (provided in no particular order):

- Urban Drainage/Flooding
- Public Identification of Problem
- City Staff Identification of Problem (including Condition Assessment Results)
- Proximity to Critical Infrastructure
- Proximity to Critical Roadways
- Lack of Opportunity for Overland Relief

Stormwater junctions will be assigned a score from 0 to 10 for each of the evaluation criteria, 0 indicating the junction is not a priority and/or the evaluation criteria is not applicable and 10 indicating the junction is a high priority. Once individual junctions have been scored, problem areas will be identified as groupings of junctions and pipes in close proximity (by block, commercial site, school ground, etc.). Model results from the existing conditions model (existing IDF, existing boundary condition) will be used for all evaluation criteria.

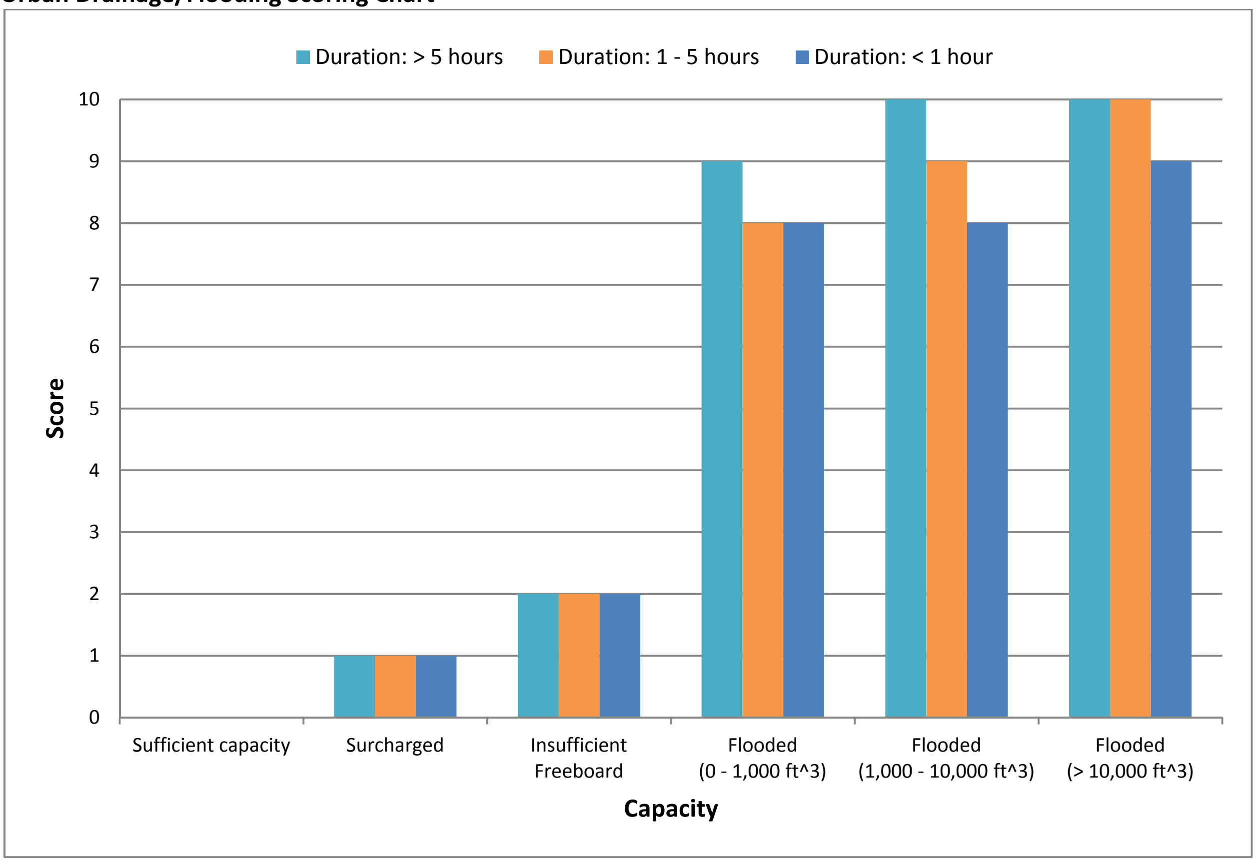
Urban Drainage/Flooding

Each stormwater junction and pipe segment in the City of Alexandria model was evaluated for capacity. Stormwater junctions will be scored based on the modeled condition of the downstream pipe according to Table 1/Figure 1. Junctions with sufficient capacity will be given a score of 0 in this category and will not be scored in the remaining categories, except where a downstream pipe segment has been identified as a maintenance issue, either by City O&M staff or by the condition assessment performed during this project.

TABLE 1
Urban Drainage/Flooding Scoring Matrix

	Duration of Flooding (Hours)		
Modeled Condition	**< 1**	**1-5**	**> 5**
Sufficient Capacity	0	N/A	N/A
Surcharged	1	1	1
Insufficient Freeboard	2	2	2
Flooding (0 – 1,000 ft^3)	8	8	9
Flooding (>1,000, ≤ 10, 000 ft^3)	8	9	10
Flooding (> 10,000 ft^3)	9	10	10

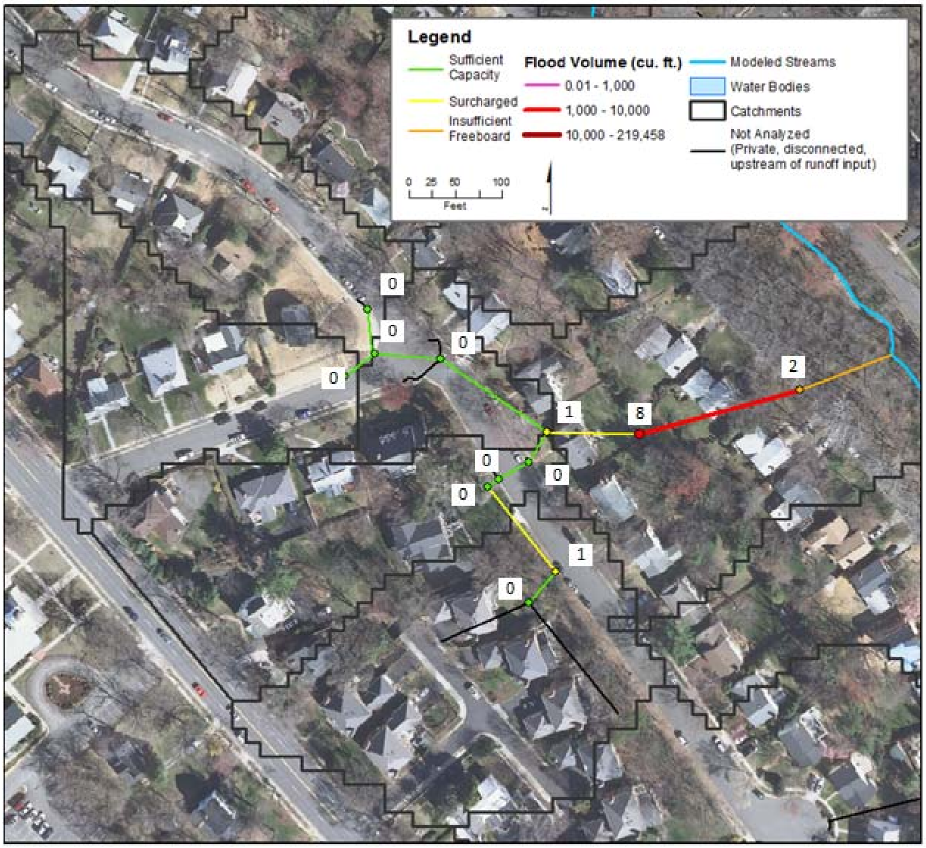
Figure 1
Urban Drainage/Flooding Scoring Chart



Urban Drainage/Flooding Example

Each junction in Figure 2 below was scored based on the modeled condition of the next downstream pipe according to the scoring described in Table 1 and Figure 1. Scores are provided on Figure 2 in a white text box adjacent to the junction. All flood durations in this example are less than 1 hour.

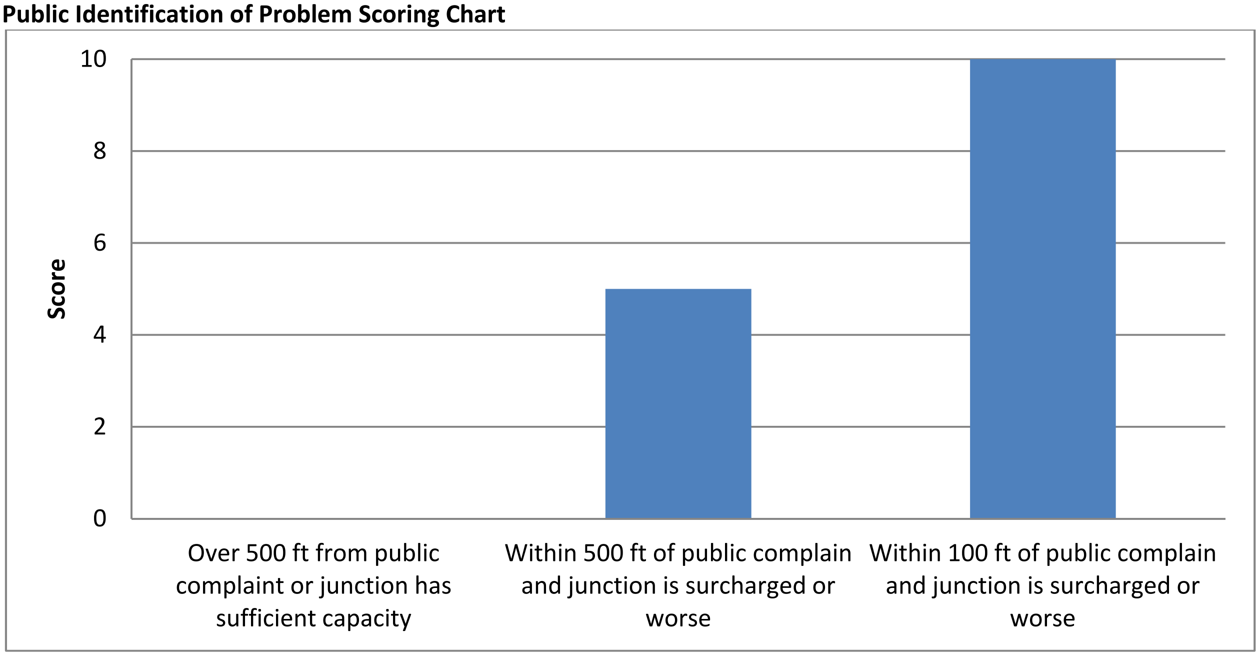
FIGURE 2
Urban Drainage/Flooding Example



Public Identification of Problem

Records of complaints by the property owners and citizens of the City of Alexandria will be reviewed and utilized to assign scores to stormwater junctions. All junctions with modeled condition of surcharged, insufficient freeboard, or flooded that are within 100 feet and 500 feet of a public complaint will receive a score of 10 and 5 respectively as shown in Figure 3.

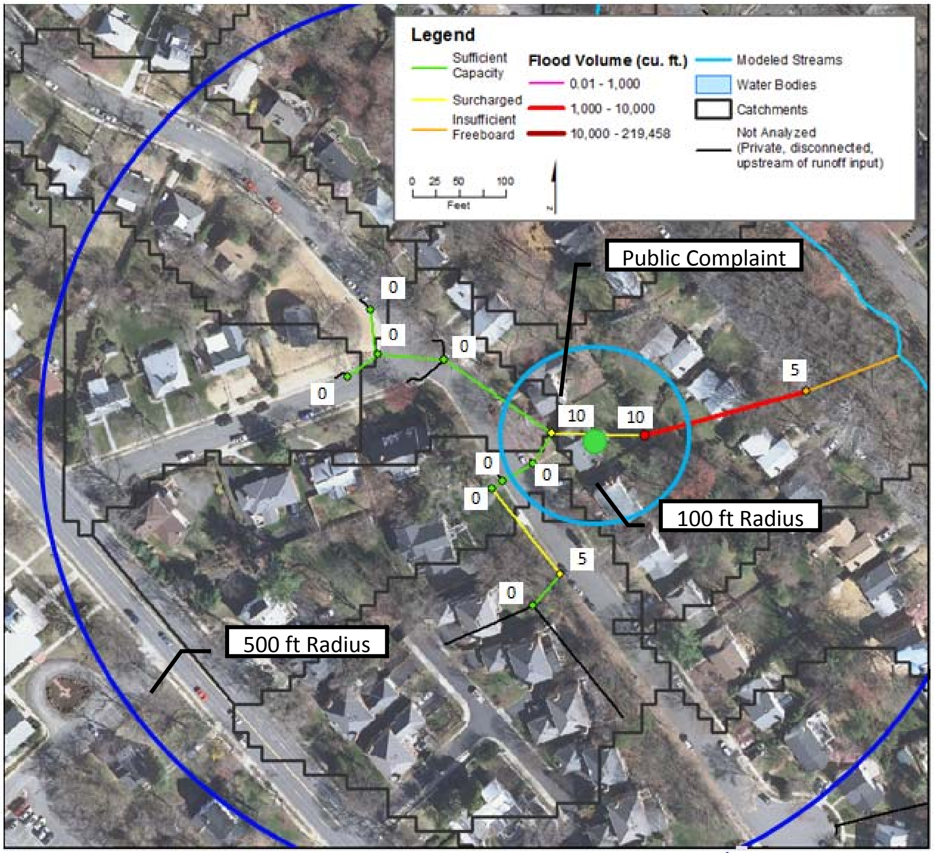
FIGURE 3
Public Identification of Problem Scoring Chart



Public Identification of Problem Example

As shown in Figure 4, a hypothetical public complaint falls within 100 feet of two surcharged or worse junctions and within 500 feet of two surcharged or flooded junctions, which receive scores of 10 and 5 respectively. The remaining eight junctions shown in the figure with sufficient capacity receive a score of 0, despite being within 500 feet of the complaint.

FIGURE 4
Public Identification of Problem Example

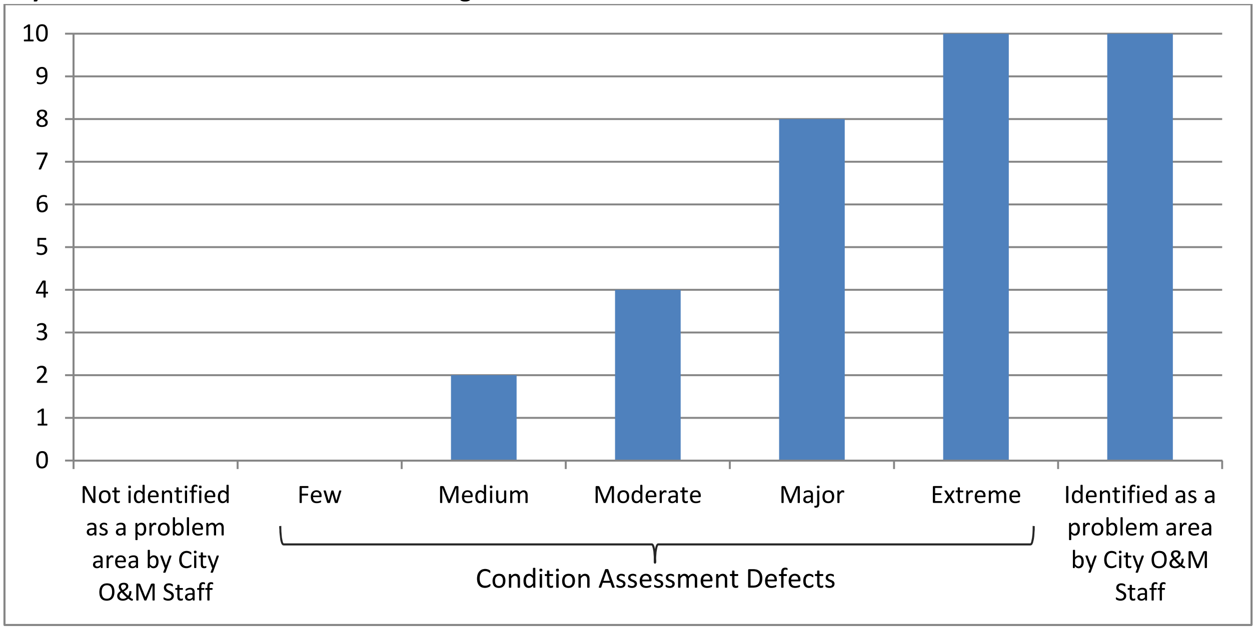


City Staff Identification of Problem

Problem areas identified by City of Alexandria maintenance staff and by the condition assessment performed in Task 3 of this project will be used to assign scores to stormwater junctions. The location of known problem areas will be delineated based on input from City staff. All modeled junctions within 100 feet of a known maintenance issue will be given a score of 10, regardless of modeled condition (sufficient capacity, surcharged, insufficient freeboard, flooded).

Junctions will also be scored based on the condition assessment results of Task 3. The storm sewer structures were inspected utilizing the Pipeline Assessment and Certification Program (PACP©) coding standards developed by the National Association of Sewer Service Companies, and were assessed further using the Sewer Condition Risk Evaluation Algorithm Model (SCREAM™). To represent the overall condition of a pipe or manhole, an overall score is derived from the scores of individual defects utilizing the SCREAM program. The scoring system is further described in the City of Alexandria Storm Sewer Capacity Analysis Four Mile Run Condition Assessment Technical Memorandum (Baker, 2013). Junctions will be scored based on the worst condition assessment category of the junction itself or the downstream pipe, as shown in Figure 5. The condition assessment results of the downstream pipe will be used to score junctions because the junction condition is dictated by the downstream pipe.

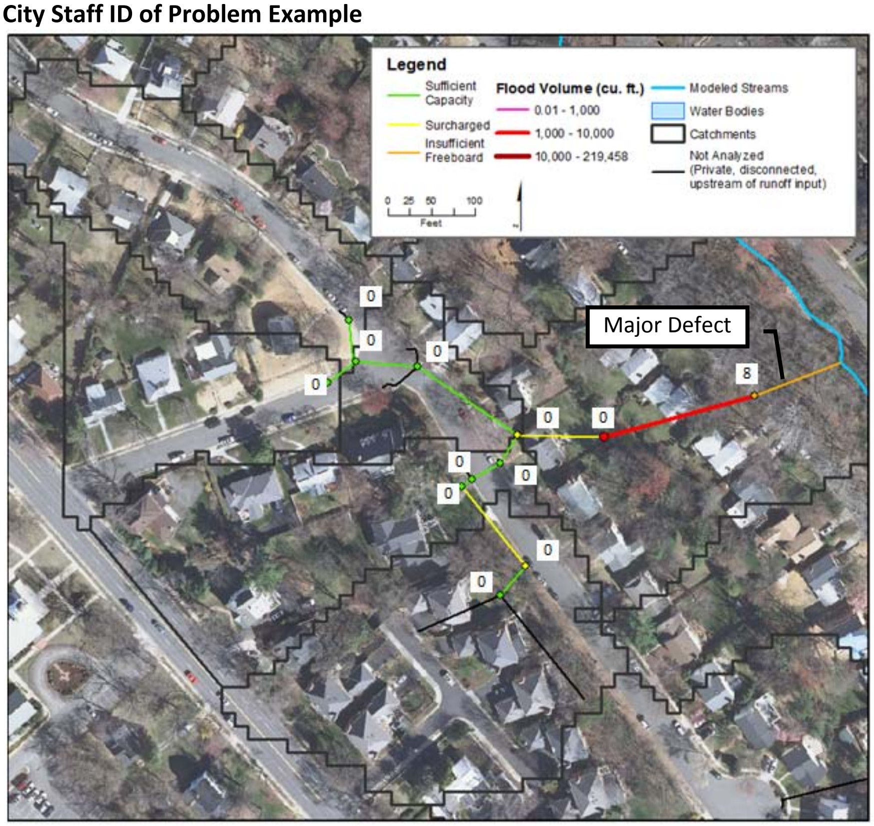
FIGURE 5
City Staff Identification of Problem Scoring Chart



City Staff ID of Problem Example

Junctions within 100 feet of a problem identified by city staff will receive a score of 10. The process will be the same as scoring problems identified by the public, described in the previous example. Additionally, junctions at the upstream end of a pipe with defects identified during the condition assessment will receive a score based on their condition. Assume the most downstream pipe in Figure 6 was found to have major defects and no other pipes were identified as a problem. The junction at the upstream end of the pipe with major defects receives a score of 8 and all other junctions receive a score of 0.

FIGURE 6
City Staff ID of Problem Example



Proximity to Critical Infrastructure

The City of Alexandria GIS department provided CH2M HILL with a shapefile containing buildings and facilities in the city identified as critical infrastructure. The shapefile contains 88 features in 17 categories, provided in Table 2.

TABLE 2
Critical Infrastructure Categories

Critical Infrastructure Category	Count
Critical Federal, State and Local Complexes	13
Critical Water and Sewer Stations	7
E911 Centers & Supporting Infrastructure	5
Elementary and Secondary Schools	21
Emergency Operations Centers (EOC)	1
Emergency Shelters	7
Fire, Rescue & Police	8
Fuel Distribution Terminals	2
Hospitals	2
Large Rehabilitation and other Critical Medical Facilities	7
Library	4
Prisons	5
Private (Home Depot, Movie Theaters)	3
Residential/Shelters (Women's/Homeless Shelters)	2
Tunnels & Drawbridges[a]	1

[a] Tunnels & Drawbridges category will be removed from evaluation

Flooded junctions that are either within 100 feet of or intersect the parcel of critical infrastructure will be selected for evaluation. The base elevation of critical infrastructure will be compared to the surface elevation of the selected junctions. Critical infrastructure within 100 feet horizontally, and with base elevation that is within 3 feet vertically of a flooded stormwater junction surface elevation will be considered at risk of being negatively impacted by capacity issues. These structures will be assigned a score greater than 0 based on the categories provided in Table 3. A sliding scale will be applied for base elevations between 0 and 3 feet from flooded stormwater junctions, as shown in Figure 7.

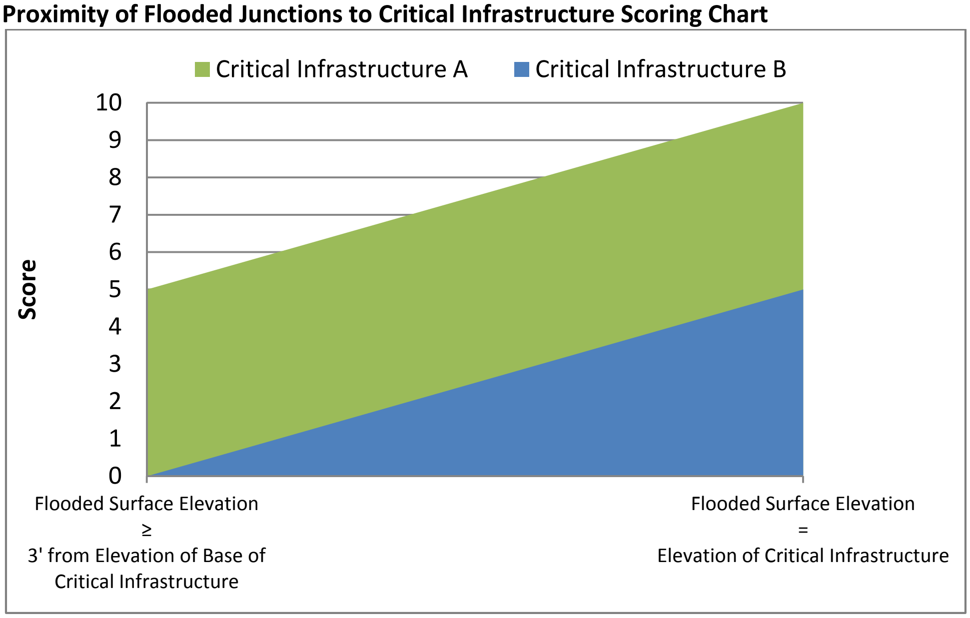
TABLE 3

Proximity of Flooded Junctions to Critical Infrastructure Scoring Matrix

Flooded Junction Location		Critical Infrastructure Category	Elevation Difference Between Building Base and Flooded Junction ≥ 3 ft	0 ft
Does not intersect parcel AND > 100’ from building	All Critical Infrastructure	All Critical infrastructure categories	0	0
Intersects Parcel OR ≤ 100’ (horizontal) building	Critical Infrastructure C	Private (Home Depot/Theaters)	0	0
		Residential/Shelter (Notabene Shelter/ Homeless Shelter)	0	0
Intersects Parcel OR ≤ 100’ (horizontal) building	Critical Infrastructure B	Elementary and Secondary Schools	0	5
		Fuel Distribution Terminals	0	5
		Libraries	0	5
		Prisons	0	5
	Critical Infrastructure A	Critical Federal, State and Local Complexes	5	10
		Critical Water and Sewer Stations	5	10
		E911 Centers & Supporting Infrastructure	5	10
		Emergency Operations Centers (EOC)	5	10
		Emergency Shelters	5	10
		Fire, Rescue & Police	5	10
		Hospitals	5	10
		Large Rehabilitation and other Critical Medical Facilities	5	10

FIGURE 7

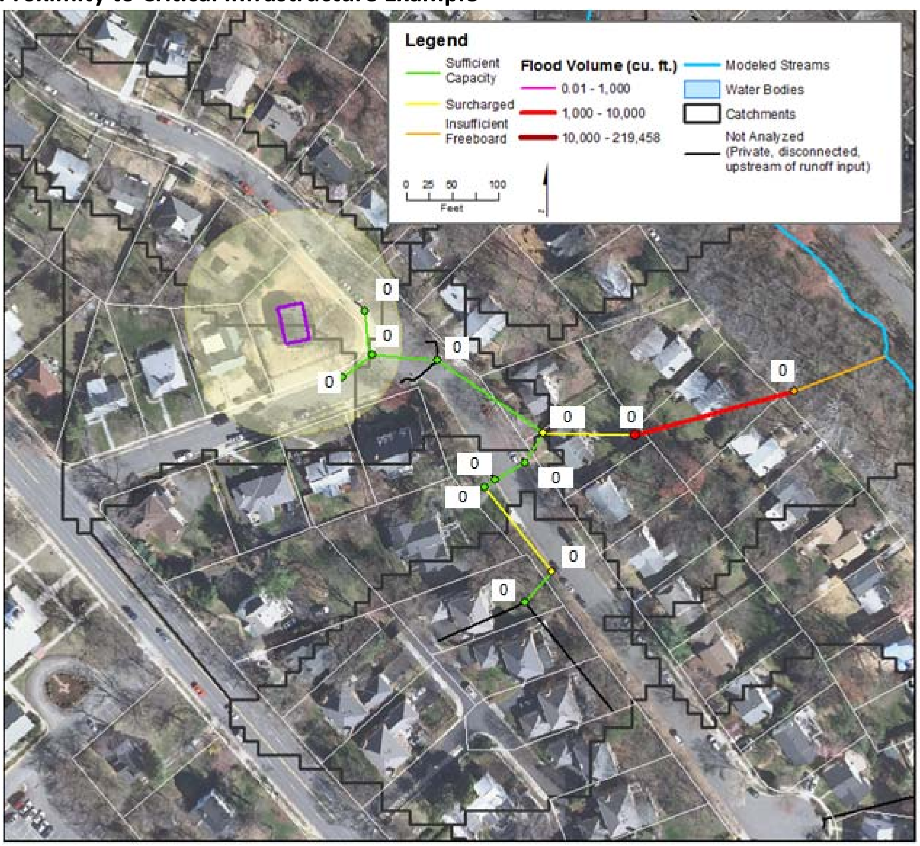
Proximity of Flooded Junctions to Critical Infrastructure Scoring Chart



Proximity to Critical Infrastructure Example

As a hypothetical example, assume the building under the purple box in Figure 8 below is a Fire Station, which falls in critical infrastructure group A. All flooded junctions within 100 feet (transparent yellow polygon) or intersecting the parcel the building falls in (white lines) will receive a score between 5 and 10 depending on the elevation difference between the base and the surface elevation of the junction. All other junctions will receive a score of 0 because they do not intersect the critical infrastructure building's parcel or are over 100' from the building's base. The average base elevation is 165 feet and the three points within 100 feet of the building are 151, 149, and 150, from top to bottom. Since there is more than 3 feet between the elevation of the building and the flooding, all points will receive a score of 5. If, for example, one of the junctions were at an elevation of 164, a foot below the building base, it would receive a score of 8.33 based on the sliding scale. However, since there is only one flooded junction in this example, and it is outside the 100 foot buffer, it receives a score of 0. The remaining junctions receive a score of 0 because they are not flooded and do not fall within 100 feet of any critical infrastructure.

FIGURE 8
Proximity to Critical Infrastructure Example



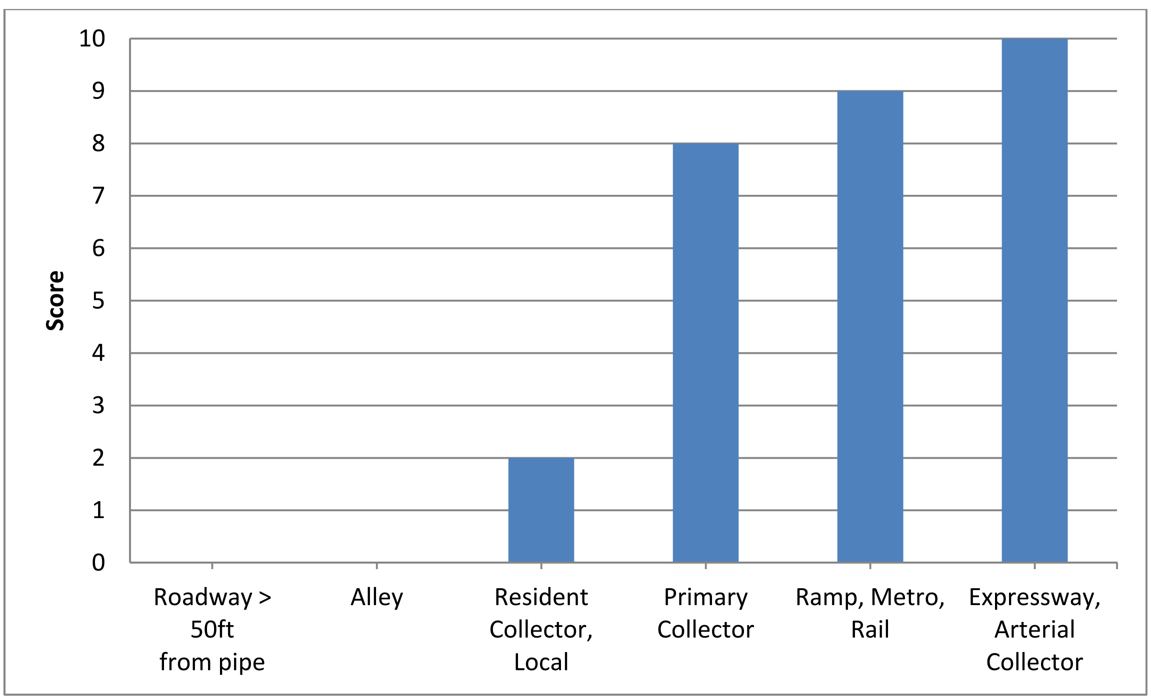
Proximity to Critical Roadways

A 50 foot buffer will be applied to all roadway centerlines to identify problem areas in or near roadways. A score of 0 will be given to all stormwater junctions over 50 feet away from road centerlines. Scores will be applied to flooded stormwater junctions within 50 feet of roadways based on the roadway category, as outlined in Table 4 and graphed in Figure 9.

TABLE 4
Proximity of Flooding to Critical Roadways Scoring Matrix

Roadway Location	Roadway Category	Score
> 50 from flooding	All Roadway Types	0
≤ 50 feet from flooding	Alley	0
	Local	2
	Resident Collector	2
	Primary Collector	8
	Metro	9
	Ramp	9
	Rail	9
	Expressway	10
	Arterial Collector	10

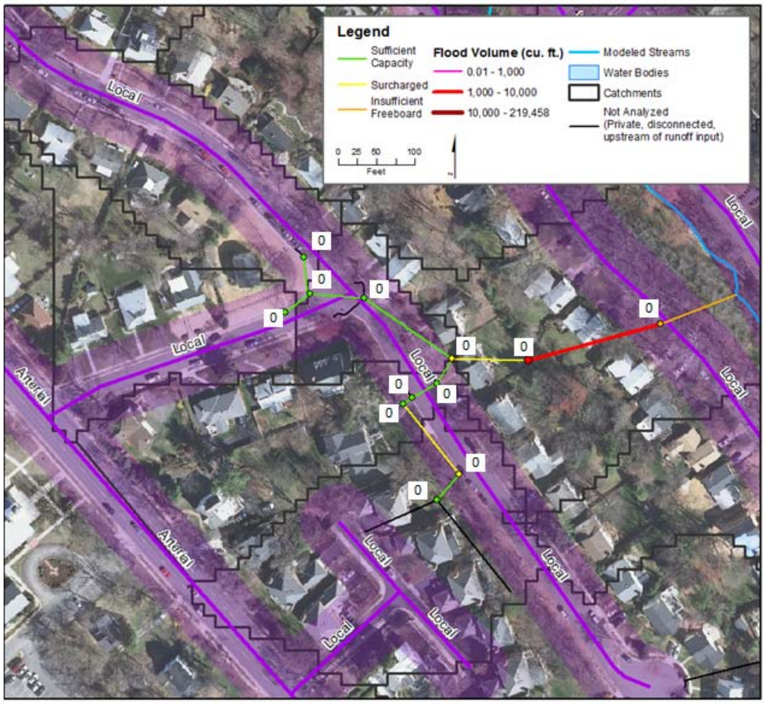
FIGURE 9
Proximity of Flooding to Critical Roadways Scoring Chart



Proximity to Critical Roadways Example

In this example, the majority of the roadways near the stormwater network are classified as 'local', as shown in the street labels in Figure 10. The streets, represented as purple lines, are shown with a 50 foot buffer. Flooded junctions intersecting the 50 foot buffer of a local street would receive a score of 2, as described in Table 4 and Figure 9. However, since there is only one flooded junction in this example, and it is outside the 50 foot buffer, it receives a score of 0. The remaining junctions receive a score of 0 because they are not flooded and do not fall within 50 feet of any roadway.

FIGURE 10
Proximity to Critical Roadways Example



Opportunity for Overland Relief

Opportunity for overland relief will be evaluated using several criteria: proximity to open channels, average catchment slope, and flood volume. Flooded junctions near an open channel (within 250 feet), flooded junctions in a catchment with a large average slope (over 4 percent), or flooded junctions in a roadway with capacity to store the flood volume (assuming a standard 6 inch curb, 25 foot wide street, 3% slope to crown, and a length of storage equal to the length of the next downstream pipe) will be given a score of 0 to indicate there is opportunity for overland relief of flooding. Flooded junctions that are not close to a stream (over 250 feet), located in catchments with a small average slope (less than 4 percent), located in streets that do not have sufficient storage capacity, or junctions that are not located in or near streets will receive a score greater than zero to indicate there is a higher potential for flood damage because floodwaters cannot escape to a stream or be contained within the road cross section. The scoring system is provided in Table 5. The three criteria will be applied independently and the average of the scores will be applied to the junction to indicate the fact that some overland relief is available.

TABLE 5
Opportunity for Overland Relief Scoring

Opportunity for Overland Relief	Score
Average Catchment slope >= 4%, flooded junction < 250 ft from open channel, and flood volume < storage space available on roadway	0
Average Catchment slope >= 2%, <4%	5
Average Catchment slope < 2%, Flooded junction > 250 ft from open channel and flood volume > storage space available on roadway	10

Note: Criteria will be applied independently and the average of the three category scores will be applied to the junction.

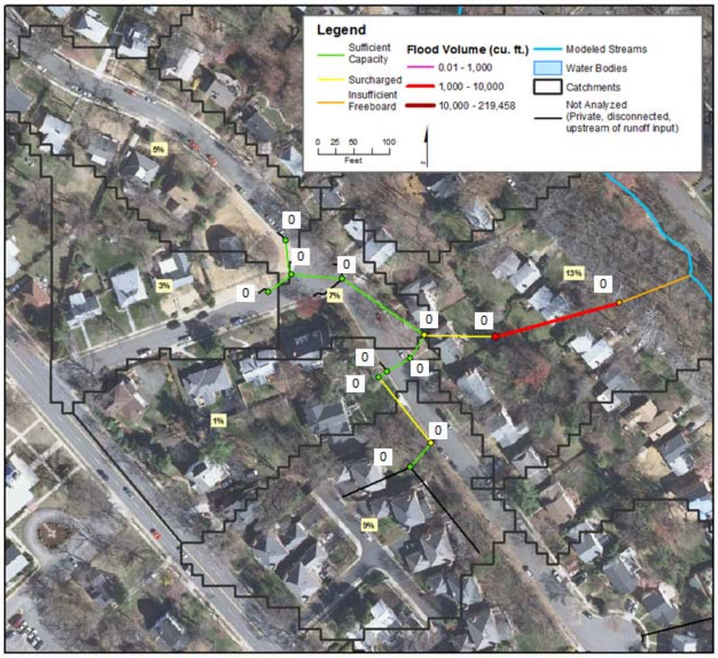
Opportunity for Overland Relief Example

The example below shows how opportunity for overland relief will be evaluated. Three separate criteria, average catchment slope, proximity to an open channel, and available storage space will be examined separately and scored, and then the average of the 3 scores will be applied to the junction.

Catchment Slope

In the example below (Figure 11), 6 catchments are defined for the stormwater network, with slopes ranging between 1% and 13%. There is only one flooded junction in this area, located in a catchment with 13% slope. Since this slope is over 4%, the junction receives a score of 0. All other junctions receive a score of 0 because there is no flooding.

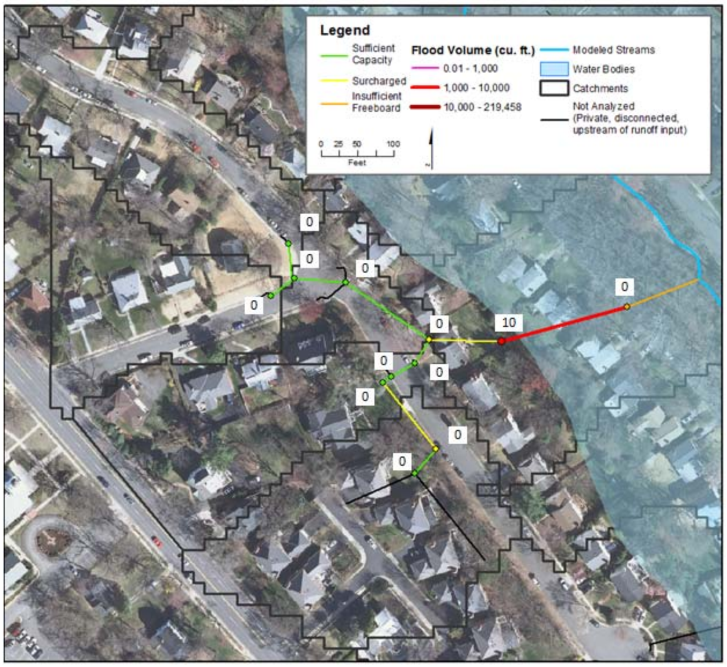
FIGURE 11
Catchment Slope Example



Proximity to an Open Channel

The transparent blue polygon in Figure 12 represents the 250 foot buffer on the open channel the storm drainage network discharges to. The one flooded junction is outside the 250 buffer, and therefore receives a score of 10. All other junctions are not flooding and receive a score of 0.

FIGURE 12
Proximity to Open Channel Example

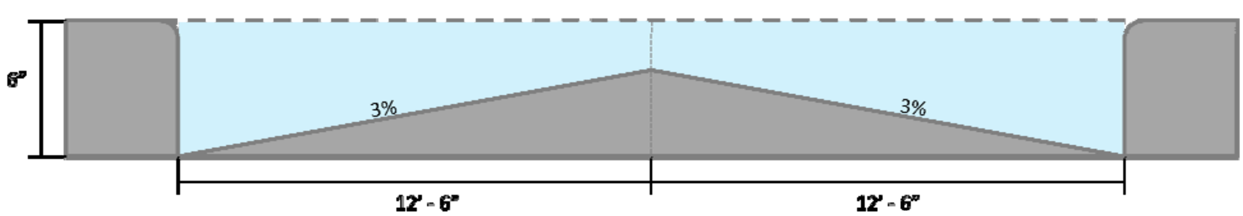


Storage Available on Roadway

The location of junctions will be analyzed to determine whether they are in the roadway, assuming that anything within 10 feet of the roadway polygon layer is close enough to the road that storage could be utilized. Storage space available on the roadway will be calculated assuming a typical road cross section shown in Figure 13; standard 6 inch curb, 25 foot wide roadway with 3% slope to the crown, and length equal to the length of the downstream pipe (an approximation of the distance to the next inlet, although in some cases the next junction may not be an inlet). The one flooded junction in this example is not located in the roadway, and therefore will receive a score of 0, along with the junctions that are not flooded.

For the sake of an example, assume a manhole is flooded with 2,000 ft^3 and calculate the storage volume available in the roadway. The downstream pipe is 116 feet long. The standard road cross section, shown below, is 7.8 ft^2. The resulting storage volume is 905 ft^3. Since the flood volume (2,000 ft^3) is greater than the available storage volume (905 ft^3), the junction receives a score of 10. The junction would receive a score of 0 if the flood volume could be contained in the available storage space.

FIGURE 13
Typical Road Cross-section



Combination of Overland Relief Criteria

The average of the three criteria scores (average catchment slope, proximity to an open channel, and storage available on roadway) will be applied to the junction. In the example provided in this section, only one junction is flooded. This junction is located in a catchment with 13% slope (score=0), more than 250 feet from a stream (score=10), and more than 10 feet from a roadway (score=0), resulting in an average score of 3.33, indicating there is moderate opportunity for overland relief of the flood waters. All other junctions are not flooding and receive scores of 0.

Problem Area Evaluation Criteria Weighting

After junctions are scored in each evaluation criteria category, weights will be applied to represent the relative importance of each category and scores will be converted to a 100 point score for ease of interpretation. Criteria weights were provided by each City of Alexandria staff member present at the Task 4 kickoff workshop held November 14, 2012, based on a 100 point scale, with 100 as most important. The City staff average weight for each category is provided in Table 7. A table of weights from all Task 4 workshop participants is provided in Attachment A. The weights were then normalized before being applied to the problem areas.

TABLE 7
Problem Area Evaluation Criteria Weights

Problem Area Evaluation Criteria	Weight	Normalized Weight	Criteria Weight Percent
Urban Drainage/Flooding	90	100	23.1
Public ID of Problem	73	81	18.8
City Staff ID of Problem	75	83	19.3
Proximity to Critical Infrastructure	58	64	14.9
Proximity to Critical Roadways	38	42	9.8
Opportunity for Overland Relief	55	61	14.1
Total	**389**	**432**	**100**

Weighting Example

For demonstrative purposes, a total weighted score will be computed for the flooded junction in the example provided. The scores for each evaluation criteria, weights, weighted score and total score are provided in Table 8.

TABLE 8
Weighted Score Example

	Score (10 point scale)	Criteria Weight Percent	Weighted Score (Score *10*Norm. Weight)
Urban Drainage/Flooding	8	23.1	18.5
Public ID of Problem	10	18.8	18.8
City Staff ID of Problem	0	19.3	0.0
Proximity to Critical Infrastructure	0	14.9	0.0
Proximity to Critical Roadways	0	9.8	0.0
Opportunity for Overland Relief	3.3	14.1	4.7
		Total (100 point scale)	**42.0**

Selecting Problem Areas

After scoring each junction in the watershed, pipes will be grouped together based on location. Junctions with higher scores in close proximity to one another (i.e. on the same block or consecutive blocks, on an industrial site, school grounds, commercial sites, etc.) will be grouped together to form problem areas. The goal will be to develop solutions for the highest priority problem areas in the watershed. Solutions will then be scored and evaluated using methods described in the following section of this TM.

Solution Evaluation

Solutions will be developed for the priority problem areas identified using the problem area evaluation criteria described in the previous section. Solutions will be prioritized based on the following set of criteria (provided in no particular order):

- Urban Drainage/Flooding
- Environmental Compliance
- EcoCity Goals/Sustainability
- Social Benefits
- Integrated Asset Management
- City-wide Maintenance Implications
- Constructability
- Public Acceptability

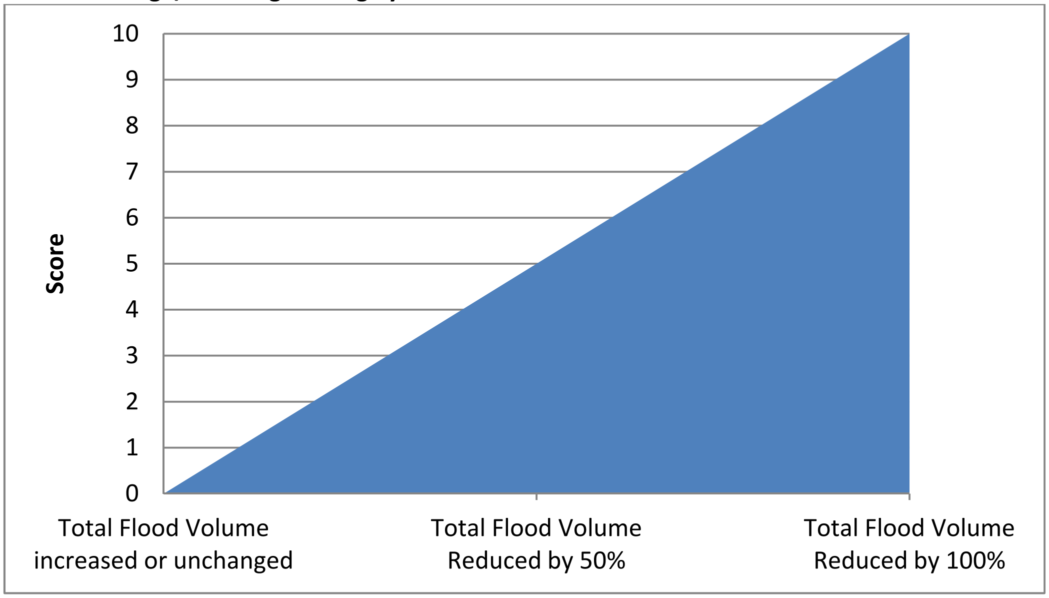
Solutions will be assigned a score from 0 to 10 for each of the evaluation criteria, 0 indicating the solution does not address the criteria and 10 indicating the solution addresses it fully. Project cost is not included in the solution evaluation because it is accounted for separately during the cost-benefit analysis.

The scoring presented in this TM describes both the generalized approach to scoring all criteria and, where applicable, the specific approach to scoring the three technologies examined during the CASSCA Task 4 analysis: conveyance capacity improvements, storage to detain peak flows from entering the downstream conveyance, and green infrastructure to reduce runoff volumes and peak flows. The generalized approach can be applied to potential future projects in the City of Alexandria, providing the same basis for scoring the benefit of potential future projects as is used for scoring projects analyzed during the Task 4 work of this study. The specific approaches presented in this TM describe how the generalized approach will be applied to the projects and project types analyzed during Task 4.

Urban Drainage/Flooding

A solution will be evaluated to determine whether flooding within the problem area was improved with its implementation and whether it created additional flooding downstream. The total flood volume from the existing conditions model (existing IDF, existing boundary condition) associated with all pipes within the problem area will be compared to the total flood volume in the solution model. Scores will be assigned on a sliding scale from 0 to 10 based on the percent reduction in total flood volume, as shown in Figure 14. Since this criterion is scored using model results, Task 4 solutions will be scored according to the generalized approach described in this section.

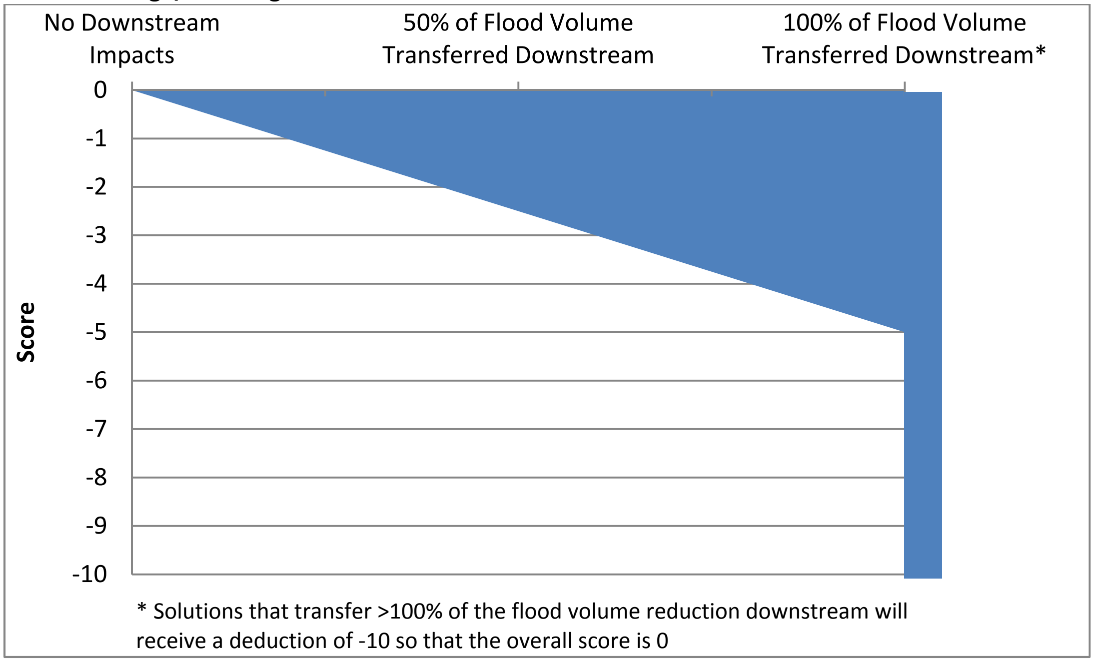
FIGURE 14
Urban Drainage/Flooding Scoring System



To account for flooding increases downstream of a problem area due to implementation of a solution, a deduction score between 0 and 5 will be applied to the urban drainage/flooding score. If the flood volume transferred downstream is greater than the volume reduction achieved in the problem area, the problem area automatically receives a score of 0 for the urban drainage/flooding criterion.

The deduction will be calculated based on the increased volume of incremental flooding caused downstream relative to the reduction in flood volume in the problem area. For areas where multiple solutions are contributing to flooding downstream, the incremental flood volume will be apportioned based on the incremental peak flow contributed by each problem area in question. The urban drainage/flooding deduction is illustrated in Figure 15. There may be instances where solutions transfer more than 100% of the flood reduction volume downstream. These solutions will receive an automatic deduction of 10 and is denoted by the rectangular bar on the far right side of Figure 15. It is worth noting that neither storage nor green infrastructure solutions should transfer flood volume downstream.

FIGURE 15
Urban Drainage/Flooding Deduction



Urban Drainage/Flooding Example

A problem area is outlined in yellow in Figure 16. The pipes in the figure are symbolized by the change in flood volume between the existing conditions model and the model including conveyance solutions. Blue and green lines indicate the flood volume is reduced by implementing the solution while pink and red lines indicate the flood volume is increased. Assume the total flood volume within the problem area in the existing conditions model is 400,000 ft^3 and the conveyance solution for the problem area reduces the total flood volume down to 200,000 ft^3. This is a 50% reduction in flood volume, which translates to a score of 5 on a 0 to 10 scale.

Though the conveyance solution decreases flooding in Problem Area A, some of that flooding is transferred downstream as is apparent with the pink and red lines outlined in orange in Figure 16. There are two problem areas contributing flow (Problem Area A and Problem Area B), so the increased flooding must be allocated to each problem area. This is accomplished by allocating the increase in flood volume downstream to each problem area based on the incremental peak flow coming from each problem area.

Assume the incremental flood volume (i.e., the additional volume of flooding caused by implementing the conveyance solutions) in the area outlined in orange is 10,000 ft^3. If the incremental peak flow (i.e., the increase in peak flow caused by implementing the conveyance solution) from Problem Area A for the conveyance solution is 80 cfs and the incremental peak flow from Problem Area B is 20 cfs. This would allocate 80%, or 8,000 ft^3, of the incremental downstream flood volume to Problem Area 1 and 20%, or 2,000 ft^3, to Problem Area B.

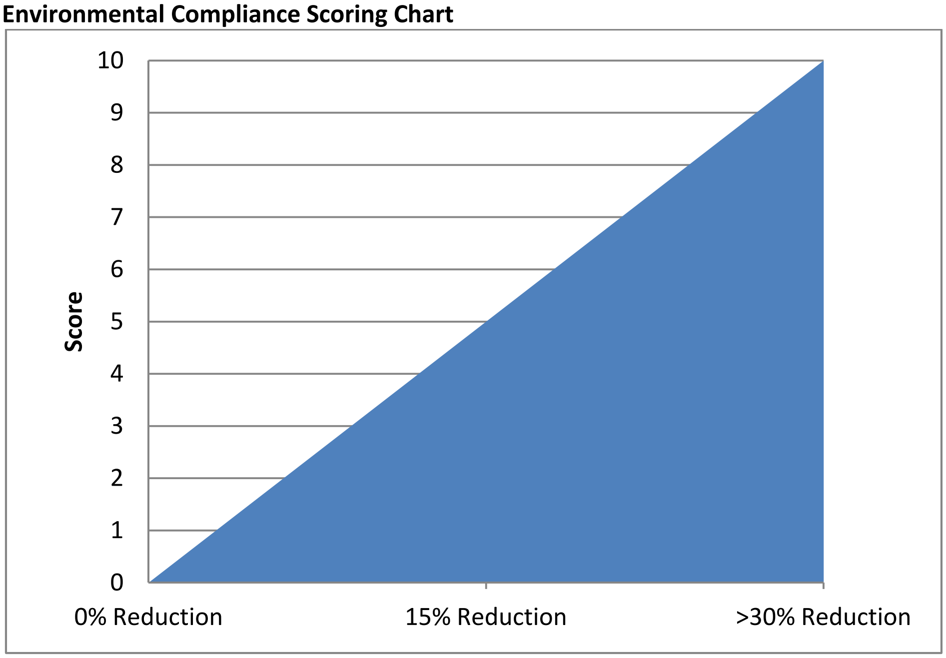
This is translated into a score by determining what percentage of the problem area's flood volume reduction it represents. In other words, what percentage of the original flood volume (flood volume in the existing conditions model) was transferred downstream. The existing conditions flood volume in Problem Area A was reduced by 200,000 ft^3, so the 8,000 ft^3 that was transferred downstream is 0.4% of the flood volume reduction. This translates to a score of 0.2 on a scale of 0 to 5. Subtracting this deduction from the score of 5 representing the 50% flood volume reduction in the problem area, the total Urban Drainage/Flooding score for problem area 1 is 4.8.

FIGURE 16
Urban Drainage/Flooding Scoring Example

Environmental Compliance

Solutions will be evaluated for environmental compliance based on reduction in stormwater volume, which is directly related to pollutant load reduction. Reduction in stormwater volume will be evaluated in the model as the total runoff from the catchments in the project area and compared to the existing conditions runoff results. Environmental compliance scoring is shown in Figure 17.

FIGURE 17
Environmental Compliance Scoring Chart



Since the hydrologic model is not altered for the conveyance or the storage solutions, the stormwater runoff volume in those models is the same as the stormwater runoff volume in the existing conditions model. This is a 0% reduction in stormwater runoff volume, which corresponds to a score of 0. The three levels of green infrastructure examined in Task 4 will be scored between 0 and 10 based on the sliding scale from 0 to 30 percent or greater reduction in stormwater runoff volume.

Eco-City Goals/Sustainability

The City of Alexandria has developed a set of Eco-city goals in an effort to make the city a more sustainable and desirable place to live. The Eco-city/Sustainability goals included in this evaluation include:

- Preservation and maximization of existing green and open space
- Creation of new green space with increased tree canopy and vegetation
- Increased opportunity for mass transit, walking, or biking
- Conservation of resources through rainwater harvesting/water reuse
- Expansion of public education
- Mitigation of climate change impacts

The City's Eco-City charter includes additional goals that were not included in this evaluation. Stream restoration was removed from this list due to the inability to scale this effectively across the city. Stream daylighting was not included in the list of acceptable technologies for examination during this evaluation. Improvement of water quality through CSO or runoff reduction was also removed from the list because water quality benefits are captured in the Environmental Compliance criterion.

Solutions will be evaluated based on the number of goals a given solution achieves, as shown in Table 8.

TABLE 8
Eco-City Goals/Sustainability Scoring

	Score
Does not meet any Eco-city goals	0
Provides groundwater recharge and baseflow enhancement	0
Meets at least 1 of the 6 goals	4
Meets at least 2 of the 6 goals	6
Meets at least 3 of the 6 goals	8
Meets at least 4 of the 6 goals	10

The Eco-City Goals/Sustainability scoring will be applied based on project type and location. Conveyance and Storage solutions do not meet any Eco-City/Sustainability Goals and will be given scores of 0. Actual conveyance and storage solutions could be paired with sidewalk, green space, or other projects to meet Eco-City goals; however it was assumed this would not be applicable to the typical project. Green infrastructure projects will be scored based on their location.

In general, there is greater opportunity to meet Eco-City goals in public spaces and fewer opportunities in residential spaces. Green Infrastructure projects in public spaces will generally meet a greater number of Eco-City Goals due to their potential for preservation, maximization, and creation of green space, contribution to increased opportunity for walking or biking, conservation of resources, and mitigation of climate change impacts. The scoring to be used for this criterion is shown in Table 9.

TABLE 9

Eco-City Goals/Sustainability Scoring for Task 4

	Score
Storage Solutions	0
Conveyance Solutions	0
Green Infrastructure in Residential Areas	4
Green Infrastructure in Commercial Areas	6
Green Infrastructure in Public Spaces (Schools/Parks/Government Buildings)	8

Social Benefits

Solutions will be scored based on the number of social benefits the solution provides. Social benefits identified by the City of Alexandria include:

- Public visibility and aesthetics
- Planned transportation and pedestrian pathway objectives
- Community group interest
- Potential for research/monitoring
- Environmental Justice

Solutions will be evaluated based on the number of social benefits a given solution provides as shown in Table 10.

TABLE 10

Social Benefits Scoring

	Score
Does not provide a social benefit	0
Provides 1 identified social benefits	4
Provides 2 identified social benefits	6
Provides 3 identified social benefits	8
Provides 4 or more identified social benefits	10

For the Task 4 work in the City of Alexandria, the Social Benefit scoring will be applied based on project type and location. Conveyance and Storage solutions do not meet any Social Benefits and will be given scores of 0 unless there is a low income housing located in the problem area drainage area, in which case solutions will be given a score of 4 for meeting the environmental justice goal. Green infrastructure projects will be scored based on their location.

Green Infrastructure projects in public spaces will generally provide a greater number of Social Benefits due to their potential to improve community aesthetics, contribute to planned pedestrian pathway objectives, and provide potential for research/monitoring. In general, there is greater opportunity to provide Social Benefits in public spaces and fewer opportunities in residential spaces. Green infrastructure in low income residential areas satisfies the environmental justice goal and therefore receives a higher score than green infrastructure in other residential areas. The scoring to be used for this criterion is shown in Table 11. This scoring will be applied to the drainage area of each problem area. Since drainage areas are likely to be composed of multiple land uses, the scores will be area weighed.

TABLE 11
Social Benefits Scoring for Task 4

	Score
Storage Solutions	0
Conveyance Solutions	0
Storage Solutions in Low Income Residential Areas	4
Conveyance Solutions in Low Income Residential Areas	4
Green Infrastructure in Residential Areas	4
Green Infrastructure in Low Income Residential Areas	6
Green Infrastructure in Commercial Areas	6
Green Infrastructure in Public Spaces (Schools/Parks/Government Buildings)	8

Integrated Asset Management

The City has existing asset management programs that can be integrated with stormwater management improvement projects. The combination of projects with improvements to pipes, roads, sidewalks, and landscape/parks/open space provides greater benefit to the community with fewer disruptions and lower costs. Solutions that have the potential to fully integrate with existing projects will be given a score of 10, while solutions that do not have an integration component will be given a score of 0. Solutions that partially integrate with a planned project will be given a score of 5. This includes projects that are within or partially within the boundaries of a planned project. The scoring for Integrated Asset Management is shown in Table 12.

TABLE 12
Integrated Asset Management Scoring

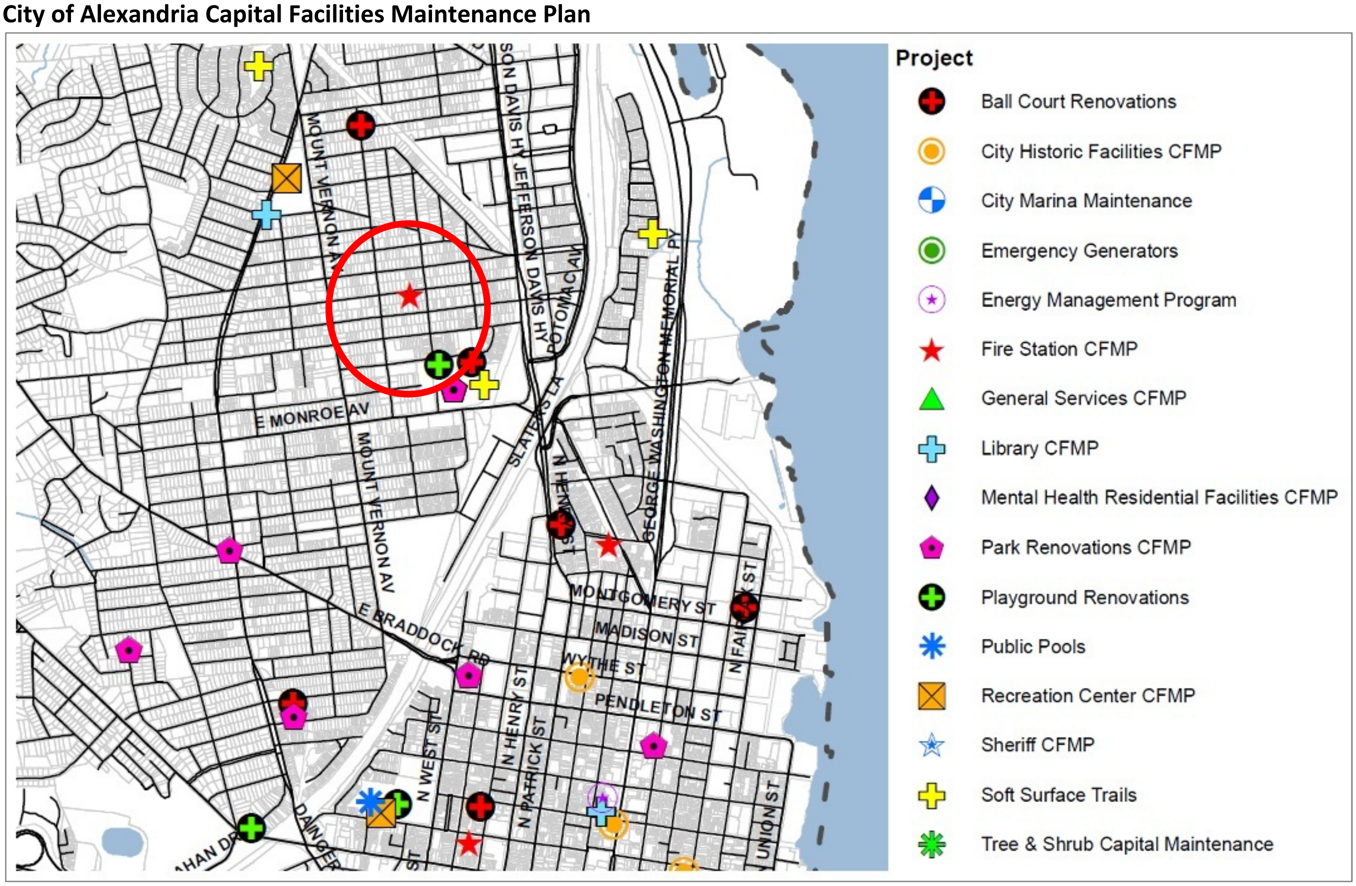
	Score
No integration with Planned Project	0
Partial Integration with Planned Project	5
Full integration with a Planned Project	10

Integrated Asset Management Example

A problem area is shown in yellow in Figure 18. The drainage area associated with the problem area is shown in light green. According to the City of Alexandria's Capital Facilities Maintenance Plan (shown in part in Figure 19), there are five planned projects in the drainage area including renovations to a ball court, park, playground, soft surface trail, and fire station. Since these projects cover a portion of the problem area's drainage area, GI projects can be partially integrated with these planned projects and will be given a score of 5. If a storage solution had been identified underneath the playground or park, the storage solution would be considered to have full integration with the planned project because the storage project footprint coincides completely with the planned capital project. Conveyance solutions in this example do not integrate with the planned projects because none of the planned projects include significant work in the street where the conveyance project is located, so the conveyance solution will be given a score of 0.

FIGURE 18
Integrated Asset Management Example

FIGURE 19
City of Alexandria Capital Facilities Maintenance Plan



City-Wide Maintenance Implications

The City has existing maintenance programs, equipment, and staff trained to perform specific duties. Solutions will be scored based on their maintenance demand over time (from low to high) to reflect the relative level of effort required to operate and maintain new stormwater management facilities. Solutions will also be scored based on their need for additional staff, equipment, or training, which would require additional investment by the City. Training may include confined space entry, which would be required for underground detention, or additional certificates for other maintenance activities. Table 13 and Figure 20 display the scoring approach for the city-wide maintenance implication evaluation criteria.

TABLE 13
City-Wide Maintenance Implication Scoring Matrix

	Need for Additional Staff/Equipment/Training		
	High	**Med**	**Low**
High long term maintenance	0	2	4
Medium long term maintenance	2	5	8
Low long term maintenance	4	8	10

FIGURE 20
City-Wide Maintenance Implication Scoring Graph

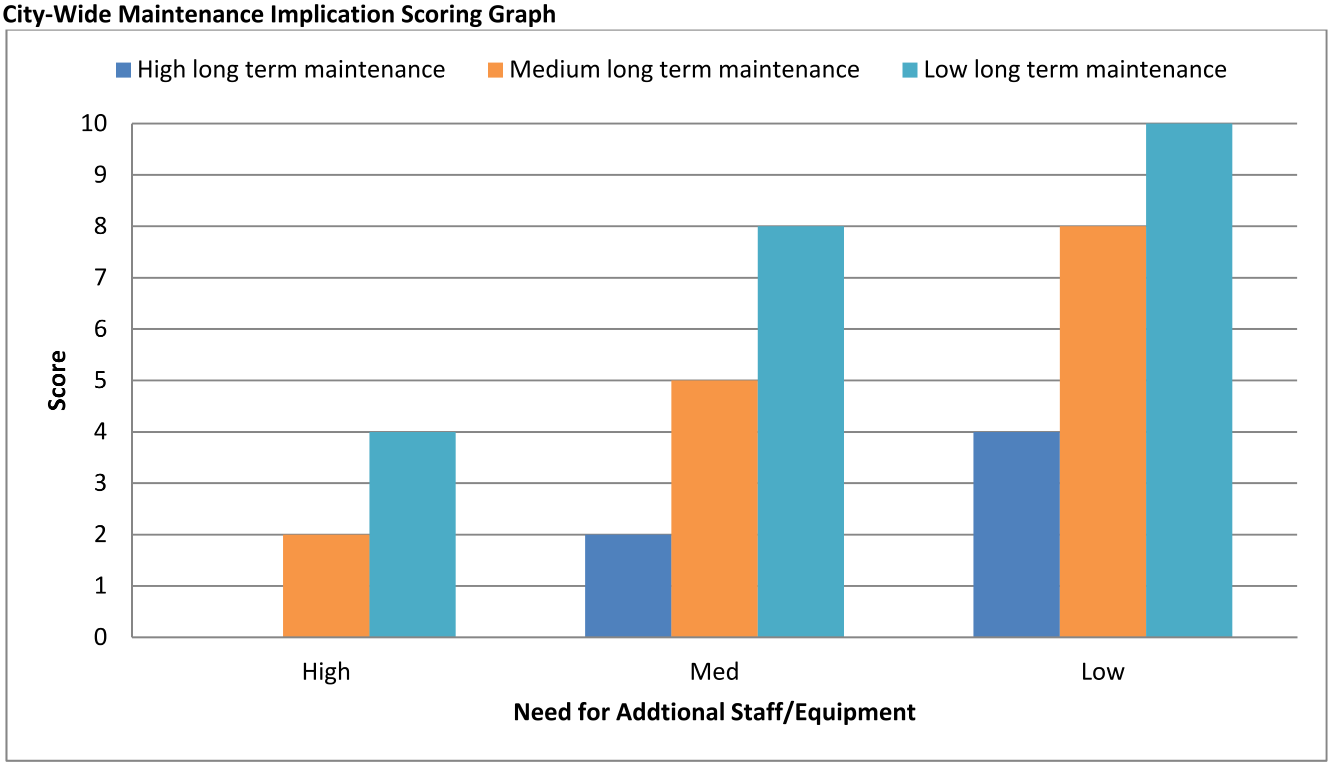


Table 14 details various typical conventional and green infrastructure stormwater management technologies and their maintenance requirements. This table also provides solution scores based on Table 13.

TABLE 14
Maintenance Requirements for SWM Technologies

Technology	Long Term Maintenance	Need for Additional Staff/Equipment/Training	Score
Bioretention/Planters	Low	Medium	8
Cisterns	High	Medium	2
Green/Blue Roofs	Medium	Medium	5
Porous Pavement	Medium	Medium	5
Surface Storage	Medium	Low	8
Ponds	Medium	Low	8
Buried Storage Tank	Medium	High	2
Pipes	Low	Low	10

Table 15 shows the scores that will be used in the Task 4 work based on technology type. Conveyance and storage solutions will be given the pipes and buried storage tank scores from Table 14 respectively. Since it is expected that the majority of green infrastructure practices that will be applicable in the study areas will be bioretention/planters, green infrastructure solutions will be given a score of 8 across the board.

TABLE 15
Citywide Maintenance Implication Scores for Task 4

Technology	Long Term Maintenance	Need for Additional Staff/Equipment/Training	Score
Green Infrastructure	Low	Medium	8
Storage	Medium	High	2
Conveyance	Low	Low	10

Constructability

Solutions will be evaluated based on the level of effort required to construct the project (utility conflicts, project size) as well as the construction activity's impact on the community (traffic, noise). The scoring for constructability is provided in Table 16. Scores will be based on technology type as well as location (road type) and project size. An example is provided for clarity.

TABLE 16
Constructability Scoring

	Score
Significant utility conflicts, noise, or traffic	2
Moderate utility conflicts, noise, or traffic	4
Minimal utility conflicts, noise and traffic	10

In general, conveyance and storage solutions will have significant utility conflicts due to their below grade construction. Green infrastructure will have minimal to moderate utility conflicts due to the relatively small size and minimal excavation required. Excavation also tends to cause significant noise pollution due to the heavy machinery required to complete the work. Conveyance projects usually occur in the roadway and will therefore cause more traffic impacts than storage or green infrastructure projects. The amount of traffic will be dependent on the road type; therefore scores will take this into account.

Constructability Example

The problem area shown in light grey in Figure 21 is in a residential area. A conveyance solution would occur in the streets, which are classified as 'local' roads. Conveyance and storage projects, which both include excavation to install below grade facilities, are likely to have moderate to significant utility conflicts. Traffic will be minimal to moderate and only impact local residents since the project is not located on a main road, though noise associated with a conveyance project is likely to be moderate to significant. Lastly, this conveyance project is substantial in size, extending over 1,000 LF of road work. Due to the utility conflicts, size, and potential for traffic, this project will be given a score of 2.

FIGURE 21
Constructability Example

Public Acceptability

Solutions will be scored using best engineering judgment based on consideration of the following public acceptability criteria:

- Reasonable Size/Scope
- Good Visibility (Government Buildings, Schools, Commercial Districts, Transportation Arteries)
- Fit to Transit Plan
- Fits in Longer Term Master Plan
- Parking Issues (Project that Improve Parking Conditions or Add Spaces)

- Potential Impact to Traffic Flow
- Stand-alone Project (dependency on other projects)
- Property owner support (business interruption)
- Fast-track potential

Projects will be scored as a having low, medium, or high acceptability rating and will be given a score of 0 to 10 as shown in Table 17.

TABLE 17
Public Acceptability Scoring

	Score
Low Acceptability Rating	0
Medium Acceptability Rating	5
High Acceptability Rating	10

Because this study is a high level planning effort and specific projects are not being fully designed or developed in all cases it would be difficult to determine public acceptability of general project types. Therefore all solutions developed in Task 4 will be given a score of 5. The public acceptability criterion is being retained for use during prioritization of projects when specific projects are selected.

Solution Evaluation Criteria Weighting

After solutions are scored in each evaluation criteria category, weights will be applied to represent the relative importance of each category. Criteria weights were provided by each City of Alexandria staff member present at the Task 4 kickoff workshop held November 14, 2012. The City staff average weight for each category is provided in Table 18. A full table of the weights from the Task 4 workshop is provided as Attachment B.

TABLE 18
City Staff Average Evaluation Criteria Weights for Solutions

Problem Area Evaluation Criteria	**Weight**	**Normalized Weight**	**Criteria Weight Percent**
Urban Drainage/Flooding	95	100	17.1
Environmental Compliance	93	98	16.8
EcoCity Goals/Sustainability	50	53	9.0
Social Benefits	40	42	7.2
Integrated Asset Management	73	77	13.2
City-wide Maintenance Implications	90	95	16.2
Constructability	60	63	10.8
Public Acceptability	53	56	9.6
Total	**554**	**583**	**100**

Attachment A

TABLE A1

Problem Area Evaluation Criteria Weights from Task 4 Workshop

	Evaluation Criteria					
Agency	**Urban Drainage/ Flooding**	**Public ID of Problem**	**Maintenance ID of Problem**	**Proximity to Critical Infrastructure**	**Proximity to Critical Roadways**	**Opportunity for Overland Relief**
City	80	100	100	70	20	20
City	100	20	20	50	50	100
City	80	100	90	50	20	50
City	100	70	90	60	60	50
Consultant	100	90	70	90	100	90
Consultant	50	50	100	80	60	70
Consultant	100	50	100	50	30	50
Consultant	40	70	70	80	90	40
Consultant	80	100	100	50	50	75
Consultant	100	70	80	80	60	50
Consultant	100	100	100	50	50	100
Consultant	75	75	20	90	65	0
City Average	**90**	**73**	**75**	**58**	**38**	**55**
Consultant Average	**81**	**76**	**80**	**71**	**63**	**59**
Overall Average	**84**	**75**	**78**	**67**	**55**	**58**

Attachment B

TABLE B1

Solution Evaluation Criteria Weights from Task 4 Workshop

	Evaluation Criteria							
Agency	**Urban Drainage/Flooding**	**Environmental Compliance**	**EcoCity Goals**	**Social Benefits**	**Integrated Asset Management**	**City-wide Maintenance Implications**	**Constructability**	**Public Acceptability**
City	100	100	50	60	90	80	70	20
City	100	100	20	20	50	80	50	20
City	100	70	70	20	70	100	80	70
City	80	100	60	60	80	100	40	100
Consultant	100	90	50	60	70	90	90	40
Consultant	100	90	80	60	90	50	50	70
Consultant	100	80	50	50	50	50	100	80
Consultant	100	90	70	50	70	50	40	20
Consultant	70	90	40	40	70	70	75	50
Consultant	90	100	80	70	90	60	50	50
Consultant	100	100	50	50	50	80	80	50
Consultant	90	80	25	25	100	75	40	50
City Average	**95**	**93**	**50**	**40**	**73**	**90**	**60**	**53**
Consultant Average	**94**	**90**	**56**	**51**	**74**	**66**	**66**	**51**
Overall Average	**94**	**91**	**54**	**47**	**73**	**74**	**64**	**52**